

CHAPTER

24

EVOLUTION

Definition:

Evolution can be defined as a series of gradual genetic and resulting morphological changes in organisms which, generation after generation leads to the production of new species.

Explanation:

- Evolution refers to the processes that have transformed life on earth from its earliest forms to the diverse form.
- Evolutionary change is based mainly on the interactions between population of organisms and their environments.
- Darwin was the first person who first explained that species were not specially created in their present forms rather they have evolved from ancestral species.
- He also proposed a mechanism for evolution through natural selection.

CONCEPTS ABOUT THE ORIGIN OF NEW SPECIES

There were two groups of scientists, in the earlier 19th century who tried to explain the diversity of life and interrelationship among living organisms.

1. Concept of Special Creation:

According to the theory of special creation all living things came into existence in their present forms especially and specifically created by Nature. Species once produced never change and exist invariably in the same form.

- Scientists who believed in the theory of special creation are known as Creationists.
- **Carolus Linnaeus** (1770-1778) was among the scientists who believed in divine creation of species.

2. Concept of Evolution:

The idea that organisms evolve through time with gradual changes, with one type of organism giving rise to another type of organism.

- Scientists who believed in the theory of evolution are known as **Evolutionists**.
- Aristotle also recognized that organisms ranged from relatively simple to very complex structures. They are evolved after change in environment.

Ideas About Evolution In Historical Context

SCIENTIST	LIFE SPAN	ACHIVEMENTS
Linnaeus	1707-1778	- Created order in the diversity of life by introducing system of classification. - He introduced binomial nomenclature for naming species. - He had a creationist idea about the origin of species (that species are unchanged permanent structures).
Lamarck	1744-1829	- Published his theory of evolution named as "Inheritance of acquired characters". - Organs modify due to use and disuse.
Malthus	1766-1834	- Published Essay on the "Principle of Population". - This essay formed the main base of the theory of natural selection.
Cuvier	1769-1832	- Contributed much to the science of palaeontology by recognizing the fossils as remains of ancient organisms. - he explained earth's history organisms exist on earth and cause destruction by natural disasters and evolution takes place.
Lyell	1797-1875	Published principle of Geology and explained the formation of sediments, river valleys, mountains etc.
Darwin	1809-1882	- Voyage of the Beagle around the earth. - Began his notebooks on the origin of species. - Wrote his essay on the origin of species. - Presented the theory of Natural Selection. - Wrote a book "On the origin of species by means of natural selection". - Also wrote a book "Descent of Man"
Mendel	1822-1884	Published papers on inheritance.
Wallace	1823-1913	- Worked as naturalist in East Asian region. - Sent his theory of evolution to Darwin.



EVALUTION FROM PROKARYOTES TO EUKARYOTES

ORIGIN OF LIFE ON EARTH

Vent Hypothesis:

- According to one of this hypothesis, first life may have begun deep in the oceans, in underwater **hot springs** called **hydrothermal vents**.
- These vents could have supplied the energy and raw materials for the origin and survival of early life forms.
- A group of bacteria, called **archaebacteria**, that tolerate temperatures up to 120°C and seem to have undergone less evolutionary change than any other living species supports this vent hypothesis.

Need of Photosynthesis:

- The nutrients produced in the primitive environment would have limited early life; so another source of nutrients was needed.
- Photosynthesis, is the process of production of organic molecules (glucose) from inorganic compounds (water and CO₂) using solar energy.

Formation of Ozone layer:

- Ozone in the upper atmosphere began to filter ultraviolet radiations from the sun and about 420 million years also enough O₃ had built up.

The first cells on earth were most likely very simple prokaryotic forms. These prokaryotes may have arisen more than **3.5 billion** years ago. Eukaryotes are thought to have first appeared about **1.5 billion** years ago.

There are two hypothesis about the origin of first eukaryotic cells.

- (a) Endosymbiont hypothesis.
- (b) Membrane invagination hypothesis,

(a) Endosymbiont Hypothesis:

Proposed by:

Endosymbiont hypothesis was first proposed by **Lynn Margulis**.

Statement:

According to this hypothesis eukaryotic membranous organelles were evolved when an anaerobic amoeboid prokaryote ingested some aerobic and stabilized them as symbionts instead of digesting them



Origin of Mitochondria:

According to this hypothesis, the aerobic bacteria were ingested by prokaryotes. They served as mitochondria, and became the sites of aerobic respiration and most efficient energy conversion in eukaryotic cells.

The possession of these mitochondria-like endosymbionts gave the advantage of aerobic respiration to the host.

Origin of Flagella:

Flagella (whip like structures) may have arisen through the ingestion of prokaryotes similar to spiral-shaped bacteria called spirochetes.

Origin of Chloroplasts:

Some heterotrophic amoeboid flagellate cells ingested autotrophic cyanobacteria (blue-green algae) and this led to the evolution of chloroplasts.

Such cells became autotrophic while others without cyanobacteria remained heterotrophic.

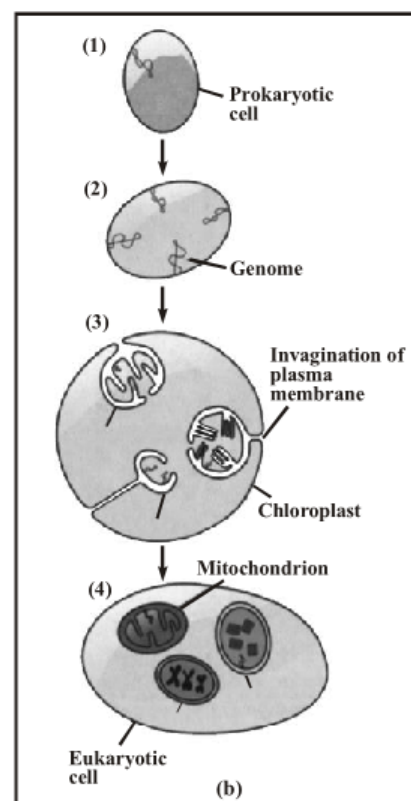
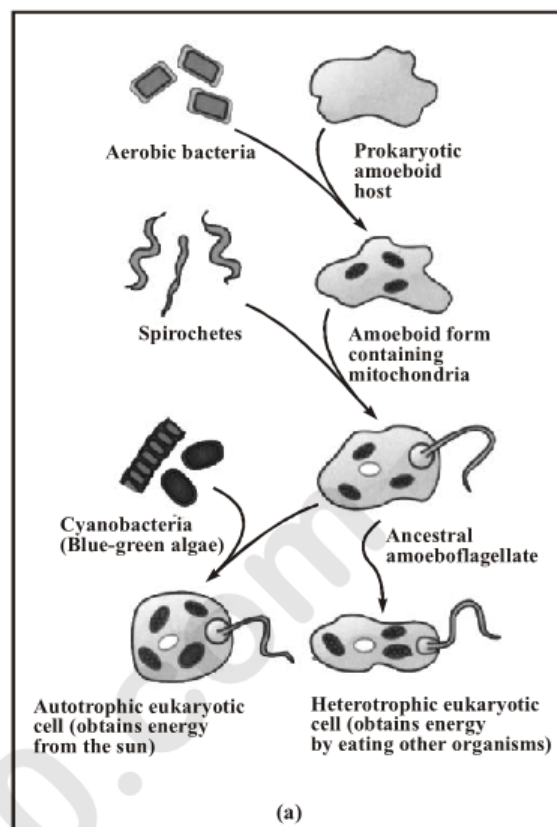
(b) Membrane Invagination Hypothesis:

This hypothesis or the evolution of eukaryotic cells proposes that the prokaryotic cell membrane invaginated (folded inward) to enclose copies of its genetic material.

This invagination resulted in the formation of several double-membrane bounded entities (organelles) in a single cell. These entities could then have evolved into the eukaryotic mitochondria, nucleus, and chloroplasts etc.

Complexities in Eukaryotes:

- The formation of the eukaryotic cell led to a dramatic increase in the complexity and diversity of life forms on the earth.
- At first, these newly formed eukaryotic cells existed only by themselves. Later, however, some probably evolved into multicellular organisms in which various cells became specialized into tissues.
- These multicellular forms then became adapted to life in a great variety of environments.



THEORIES OF EVOLUTION

Various scientists tried to explain the idea of organic evolution. A brief account is given in the table (page 2).

LAMARCK'S IDEA / LAMARCKISM

Introduction:

Jean Baptiste Lamarck (1744-1829) published his theory of evolution in 1809. Lamarck was incharge of vertebrate collection at the Natural History Museum in Paris. He presented a mechanism to explain how specific adaptation evolve by the modification of existing structures.

Use and Disuse of Organs:

Lamarck explained that those parts of the body, which are used extensively to cope with the environment, become larger and stronger, while those that are not used deteriorate (become less developed).

Examples:

Lamarck cited many examples to explain his idea.

1. Blacksmith developing a bigger biceps (muscle) in the arm that works the hammer.
2. Giraffe stretching its neck to new lengths in pursuit of leaves of upper branches of trees.

Inheritance of Acquired Characteristics:

- In this concept of heredity, the modifications an organism acquires during its lifetime can be passed along to its offspring.
- For example, the long neck of the giraffe evolved gradually as the cumulative product of a great many generations of ancestors stretching higher.

CHARLES DARWIN

Charles Darwin was born in Shrewsbury, in western England, in 1809. He got a chance, in 1830's to accompany the naturalists, in a ship named beagle, for a 5 years around the world.

VOYAGE OF BEAGLE

Darwin joined the expedition on Beagle to **South American coastline** and other parts of the world where he studied a vast variety of animals and plants.

Plants and Animals of South America:

- He observed and collected thousand of specimens of greatly diverse fauna and flora of South America.



- He noticed that the fauna and flora of the different regions of the continent had a definite South American pattern, very distinct from the life forms of Europe and other continents.
- Furthermore, the South American fossils that Darwin found, through clearly different from modern species, were more related to the living plants and animals of that continent as compared to other continents.

Fauna of the Galapagos:

A particularly puzzling case of geographical distribution was the fauna of the **Galapagos Islands**. These islands lie on the equator about 900 km west of the South American Coast.

Darwin's Book – The Origin of Species:

Darwin quickly finished his monumental book entitled “On The Origin of Species by means of Natural Selection” and published it the next year.

In this book Darwin developed two main points:

1. Descent with Modification:

- Darwin believed that all organisms are related through descent from some common ancestor that lived in the remote past.
- In the Darwinian view, the history of life is like a tree, with multiple branching and rebranching from a common trunk all the way to the tips of the living twigs.
- Terminal branches represent the current diversity of organisms.
- At each fork (point of branching) of the evolutionary tree is an ancestor common to all lines of evolution branching from that fork.

2. Natural Selection and Adaptation:

Darwin explained that populations of individual species become better adapted to their local environments through natural selection. Darwin's theory of natural selection was based on following observations.

(i) Over Production:

In almost all organisms, there is a tendency of over production i.e., production of more individuals than the environment can support due to the limitations of resources.

(ii) Struggle for Existence:

Over production leads to competition for food, space shelter, mate etc, and a struggle for existence among individuals of a population, with only a fraction of offspring surviving each generation.



(iii) Survival of the Fittest:

Better-adapted individuals will survive and produce next generation. Survival in the struggle for existence is not random, but depends in part on to hereditary constitution of the surviving individuals. Those individuals whose inherited characteristics fit them best to their environment are likely to leave more offspring than less fit individuals.

(iv) Evolution of New Species:

The unequal ability of individuals to survive and reproduce will lead to a gradual change in a population, with favourable characteristics accumulating over the generations. It ultimately results in the evolution of new species.

NEO-DARWINISM / THE MODERN EVOLUTIONARY SYNTHESIS

This is a concept where evolution is explained in terms of genetic variations with in a population.

In this view, Darwinism and Mendelism were reconciled and it was supported by discoveries and ideas from many different fields including palaeontology, taxonomy, biogeography and of course, population genetics.

Explanation:

The origin of species convinced most biologists that species are products of evolution. An important turning point for evolutionary theory was the birth of population genetics, which emphasizes the extensive genetic variation within populations and recognizes the importance of quantitative characters. With progress in population genetics in the 1930s, Mendelism and Darwinism were reconciled, and the genetic basis of variation and natural selection was worked out.

Thus a comprehensive theory of evolution that became known as the modern synthesis was developed in the early 1940s.

- This theory is also called a synthesis because it integrated discoveries and ideas from many different fields, including palaeontology, taxonomy, biogeography, and of course, population genetics.

EVIDENCES OF EVOLUTION

Evolutionary events in nature can be observed. Darwin's theory of evolution was mainly based on evidence from the geographical distribution of species and from the fossil record. However, there have been many evidences as biology progressed. New discoveries continue to validate (confirm) the evolutionary view of life.

1. Biogeography:

Biogeography is the distribution of plants and animals on different geographical regions. It is the biogeography that first suggested the idea of evolution to Darwin.

Islands have many species of plants and animals that are endemic (restricted to a region) but closely to species of nearest mainland or neighboring islands.



- Consider armadillos, the armoured mammals that live only in America. The evolutionary view of biogeography predicts that present day armadillos are modified descendants of earlier species that occupied these continents. and the fossil record confirms that such ancestors existed.
- Species of finches that existed on different islands were probably evolved from common ancestor after adaptations in their specific habitats.

2. **The Fossil Record:**

Fossils are the remains of organisms of their imprints, which are preserved in rocks. It provides a visual record in a complete series showing the evolution of an organism.

Examples:

- Evidence from biochemistry, molecular biology, and cell biology shows that prokaryotes must be the ancestors of all life and predicts that bacteria should precede all eukaryotic life in the fossil record. This idea is confirmed by fossil record because the oldest known fossils are prokaryotes.
- The different classes of vertebrate animals appear chronologically in the fossil record such as fossil fishes, the earliest vertebrates, with amphibians next followed by reptiles, then mammals and birds. This sequence is consistent with the history of vertebrate descent. The evolution of horse, camel and elephant provides an example of such a history.

3. **Comparative Anatomy:**

Anatomical similarities between species grouped in the same taxonomic category bring another support to the theory of the descent with modification.

Homologous Structures:

These are the structures, which are apparently different in various groups but perform different functions, but have common basic structural plan because they are inherited from a common ancestor.

Comparative anatomy testifies that evolution is a remodeling process in which ancestral structures that function in one capacity become modified as they take on new functions.

Examples:

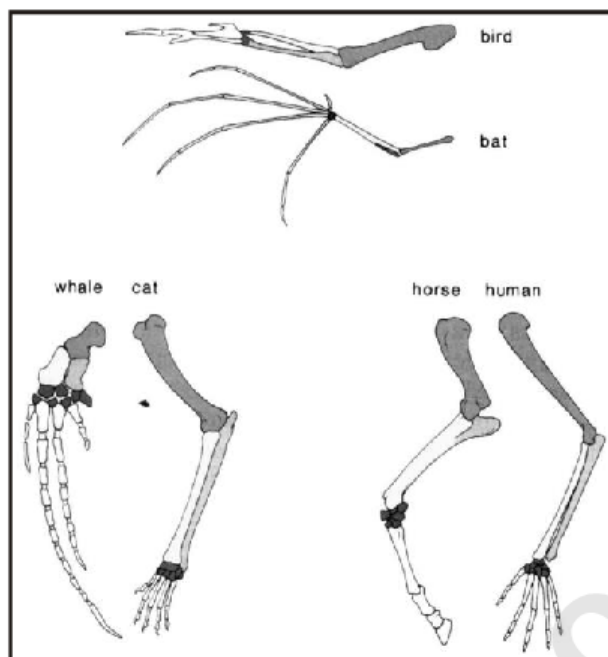
Fore Limbs of Mammals:

The same skeletal elements make up the forelimbs of human, cats, whale, bats, and all other mammals, although these appendages have different functions.

The basic similarity of these forelimbs indicates that all mammals arise from a common ancestor.

The forelegs (of cat etc), wings (of bat etc), flippers (of whale), and arms (of man etc) of different mammals show slight variations due to their specific functions.





Flowers:

The flower parts of flowering plant are homologous structures. They are considered to have evolved from leaves to form sepals, petals, stamens and carpels.

Vestigial Organs:

These are the rudimentary structures which are present in the body but apparently have no or marginal (unimportant) function.

These are probably the oldest homologous structures. Vestigial organs are historical remnants of structures that had important functions in ancestors but are no longer essential. For instance:

- (i) The skeletons of whales and some snakes retain vestiges of pelvis and leg bones of walking ancestors.
- (ii) Vermiform appendix in carnivores and man.
- (iii) Ear muscles, hair on the body, nictitating membrane and coccyx (tail bone) in man.

4. Comparative Embryology:

History of the development of an organism indicates its ancestral history. Closely related organisms go through similar stages in their embryonic development. For example, all vertebrate embryos go through a stage in which they have gill pouches on the sides of their throats.

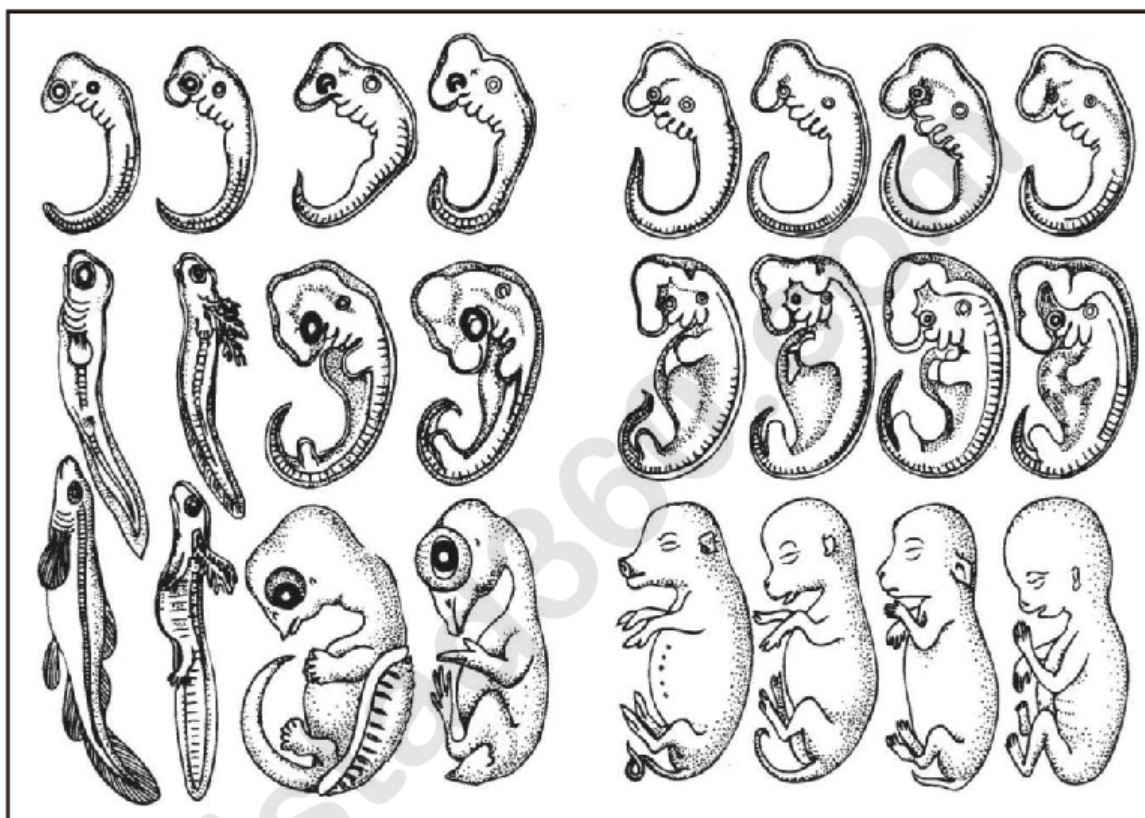
At embryonic stage of development similarities between fishes, frogs, snakes, birds, humans and all other vertebrates are much more apparent than differences.



As development progresses, the various vertebrates diverge more and more, taking on the distinctive characteristics of their classes.

In fish, for example the gill pouches develop into gills; in terrestrial vertebrates, these embryonic structure become modified for other functions, such as the Eustachian tubes that connected the middle ear with the throat in humans.

Comparative embryology can often establish homology among structures, such as gill pouches, that become so altered in later development that their common origin would not be apparent by comparing their fully developed forms.



Embryology of a few animals showing similarities

5. Molecular Biology:

Evolutionary relationship among species are reflected in their chemical constituents such as DNA and proteins (genes and gene products).

- If two species have genes and proteins with sequences of monomers that match closely, the sequences must have been copied from a common ancestor.
- Similarly, taxonomically remote organisms, such as humans and bacteria, have some protein in common. For instance cytochrome which is a respiratory protein is found in all aerobic species.
- A common genetic code brings evidence that all life is related.



NATURAL SELECTION AND ARTIFICIAL SELECTION

Natural Selection:

Natural selection is a process in which, individuals better adapted to their environment evolve, during the course of several generations.

It occurs through an interaction between the environment and the variability inherent in any population.

Artificial Selection:

Artificial selection is process in which, by repeated selective breeding, individuals better adapted to the need of man, are produced in a few years time.

- Humans have modified, the domesticated animals and plants from wild species over many generations by selecting individuals with desired traits as breeding stock.
- He wanted cows that produce more milk, chicken that lay more eggs and grows more rapidly, cattle that has more flesh crops that give more yield and are resistant to diseases.

Darwin View about Selection:

From the changes achieved by artificial selection in a relatively short period of time, Darwin postulated that natural selection operating in over vast span of time could produce the entire diversity of life.

Heritable and Non-Heritable Variations:

Natural selection can amplify (increase) or diminish only those variations that are heritable. It is important that adaptations that an organism acquires by its own actions (acquired characters) are not heritable.

Natural Selection ----- A continuous process:

The specific features evolved during natural selection are regional and timely; environmental factors vary from place to place and from time to time. An adaptation in one situation may be useless or even detrimental (harmful) in different circumstances.

An example of natural selection in action is the evolution of antibiotic resistance in bacteria.

POPULATION, GENE POOL, ALLELE FREQUENCIES AND GENOTYPE FREQUENCIES

Species:

A species is a group (or an aggregate) of populations that can interbreed freely in nature, produce fertile offspring and are reproductively isolated from other populations.

Each species has a geographical range within which individuals are not spread out evenly, but are usually concentrated in several localized populations.



Population:

A population is a localized group of individuals, found in an area, belonging to the same species, living at the same time.

A population may be isolated from others of the same species, exchanging genetic material only rarely. Such isolation is particularly confined to widely separated islands, unconnected lakes, or mountain ranges separated by lowlands.

Within a population individuals are concentrated in centers and more likely to interbreed with members of the same population than with members of other populations. Therefore, individuals near a population center are, on average, more closely related to one another than to members of other populations.

Gene Pool:

The total aggregate of genes in a population at any one time is called the population's gene pool. It consists of **all gene loci** in all individuals of the population.

Sometime the term may be restricted to all alleles of individuals of population for **one gene locus**.

Allele Frequency:

It is the relative proportion (or percentage) of different types of alleles for a trait.

For a diploid species, each locus is represented twice in the genome of an individual that may be either homozygous or heterozygous.

Fixed Allele:

If all members of a population are homozygous for the same allele, that allele is said to be fixed in the gene pool.

Genotype Frequency:

It is the relative proportion of different kinds of genotypes (homozygous or heterozygous) in population.

Example of Wild Flower:

Imagine a wildflower population with two varieties contrasting in flower colour. An allele for pink flowers, symbolized by A, is completely dominant to an allele for white flowers, symbolized by a. (suppose these are the only two alleles for this locus in the population).

Our imaginary population has 500 plants. Twenty have white flowers because they are homozygous for the recessive allele; their genotype is aa. Of the 480 plants with pink flowers, 320 are homozygous (AA) and 160 are heterozygous (Aa), since these are diploid organisms, there are a total of 1000 copies of genes for flower colour in the population. The dominant allele accounts for 800 of these genes ($320 \times 2 = 640$ for AA plants, plus $160 \times 1 = 160$ for Aa individuals).

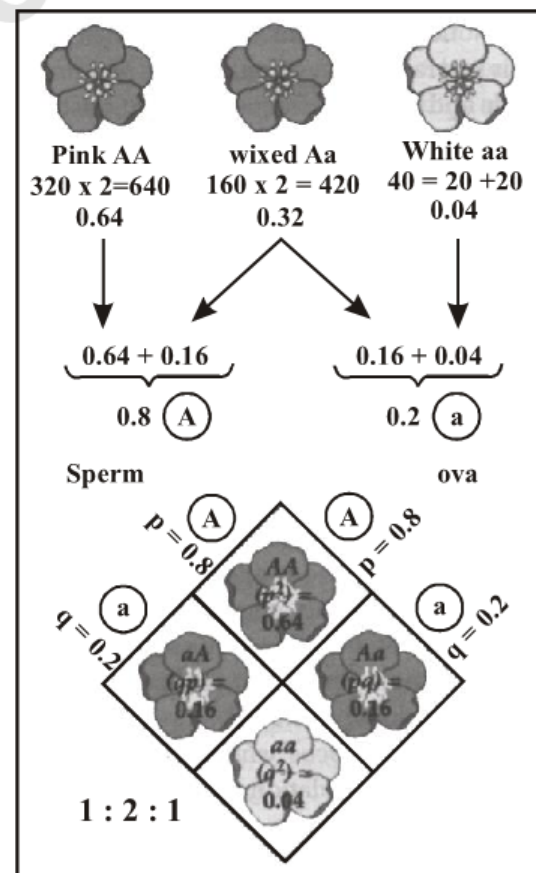


Thus, the frequency of the A allele in the gene pool of this population is 80% or 0.8. And since there are only two allelic forms of the gene, the a allele must have a frequency of 20% or 0.2.

Related to these allele frequencies are the frequencies of genotypes. In model wildflower population, these frequencies are: AA=0.64 (64%) (320 out of 500 plants), Aa=0.32 (160/500), and aa=0.04 (20/500).

• Phenotypes:	Pink		White
• Individuals	480		20
• Genotypes	AA	Aa	aa
• No. of plants	320	160	20
• Genotypic frequencies	0.64 (64%)	0.32 (32%)	0.04 (4%)
• ALLELES	A		a
• No. of alleles	800 (640 + 160)		200 (160 + 40)
• Allele frequencies	0.8 (80%)		0.2 (20%)

The Hardy-weinberg theorem. The genetic structure of a non-evolving population remains constant over the generations. Sexual recombination alone will not alter the relative frequencies of alleles of genotypes. (P = frequency of A: q = frequency of a).



HARDY – WEINBERG THEOREM

Hardy- Weinberg theorem is named after the two scientists who derived the principle independently in 1908. The frequencies of genotypes of non- **evolving populations** are described by Hardy – Weinberg theorem.

Statement:

Hardy Weinberg theorem states that “the frequencies of alleles and genotypes in a population’s gene pool remain constant over the generations unless acted upon by agents other than sexual recombination”.

- Shuffling of alleles due to meiosis and random fertilization has no effect on the overall genetic structure of population.

HARDY – WEINBERG EQUATION

A general formula, called the Hard-Weinberg equation is used for calculating the frequencies of alleles and genotypes in populations at equilibrium.

For a gene locus where only two alleles occur in a population, population geneticists use the latter “**p**” frequency of allele dominant to represent the frequency of one allele and the latter “**q**” to represent the frequency of the other allele.

In the imaginary wildflower population, $p=0.8$ and $q=0.2$

Now $p + q = 1$

The combined frequencies of all possible alleles must account for 100% of the genes for that locus in the population.

If there are only two alleles and the frequency of one is known, the frequency of other can be calculated:

If $p + q = 1$, then $1 - p = q$, or $1 - q = p$

When gametes combine their alleles to form zygotes, various combinations are formed.

- The probability of generating an **AA** genotype is **P^2** . In the wildflower population, $p=0.8$, and $P^2 = 0.64$, which indicates the probability of an a sperm fertilizing an A ovum to produce an AA zygote.
- The frequency of individuals homozygous for the other allele (aa) is **q^2** , or $0.2 \times 0.2 = 0.04$ for the wildflower population.
- There are tow ways in which an Aa genotype can arise, depending on which parent contributes the dominant allele. Therefore, the frequency of heterozygous individuals in the population is **$2pq$** ($2 \times 0.8 \times 0.2 = 0.32$, in our example).



- If we have calculated the frequencies for all possible genotypes correctly, they should add up to **1**.

Hardy Weinberg equation is actually binomial expansion of $(p + q)^2$

$$\begin{array}{ccccccc}
 (p + q)^2 & = & 1 & \Rightarrow & \text{Genotypic frequency equation} \\
 p^2 & + & 2pq & + & q^2 & = & 1 \\
 \text{AA} & & \text{Aa} & & \text{aa} & & \\
 0.64 & + & 0.32 & + & 0.04 & = & 1
 \end{array}$$

FACTORS AFFECTING GENE FREQUENCY

Gene frequency is not changed by only meiosis or sexual reproduction. Many factors can alter gene frequency. They affect proportion of homozygotes and heterozygotes enough to produce significant deviations from the proportion claimed by Hardy Weinberg principle.

1. Mutation:

Definition:

It is change in genetic material of an organism due to radiations, chemicals, or some other reasons.

- Mutation is the ultimate source of all changes.
- When genes change into new forms, it results in the change of their relative frequencies.
- Individual mutations occur so rarely that they alone do not change allele frequency much.

2. Migration:

Definition:

Movement of individuals from one population to the other.

- A very potent agent of change, migration locally acts to prevent evolutionary changes by preventing populations that exchange members from diverging from one another.
- **Emigration** (moving out of a population and **immigration** (moving into a population) cause disturbance in the gene pool.

3. Genetic Drift:

Definition:

It is the change in frequency of alleles at a locus that occurs by chance. In small populations, such fluctuations may lead to the loss of particular alleles.

- This may occur in a small population (of 100 or less individuals) when a few individual fail to reproduce and then genes are lost from population.
- Population of more than 10,000 individuals are sufficiently larger to neglect the genetic change by chance.



4. **Non-Random Mating:**

Mating is random when all male individuals have a free chance to mate with any of the female.

- But it rarely happens in nature. Individuals with certain genotypes sometimes mate with one another more commonly than would be expected on a random basis. This is called non-random mating.
- It lessens the proportion of heterozygote individuals, causing the frequencies of particular genotypes to differ greatly from those predicted by the Hardy Weinberg principle.

5. **Selection:**

Due to the differential adaptability of alleles, certain genotypes are favoured by the environment for survival. This is called selection.

- These individuals leave behind more progeny than others, and the rate at which they do so is affected by their inherited characteristics.
- Selection can be artificial or natural. In artificial selection, the breeders select the desired characters. In natural selection, the environment plays this role.
- Selection ultimately affects the proportion of various genotypes in population.

ENDANGERED SPECIES

Definition:

A species which is in imminent danger of extinction throughout its range (where it lives) is called endangered species.

Threatened Species:

A threatned species is that which is likely to become endangered in the near future.

CAUSES OF EXTINCTION

Extinction has been the fate of most plant and animal species. It is a natural process that will continue. In recent years, however, the threat to the welfare of wild plants and animals has increased dramatically due to following reasons:

Habitat Destruction:

The most obvious cause of extinction of species is habitat destruction.

- Tropical rain forests, the most threatened areas on the earth, have been reduced to 44% of their original extent. In certain areas, such as Ecuador, forest coverage has been reduced by 95%.
- More and more areas are being brought under cultivation.



- Cities are growing, industries are being established and roads are constructed which destroys the natural habitats of wild life.
- Habitats other than rain forest-grassland, marshes, deserts, and coral reefs – are also being seriously threatened.

This decrease in habitat has resulted in tens of thousands of extinctions.

- Climate change
- Pollution
- Invasions from foreign species
- Deserts, sub-mountainous tract, Wetlands are habitats in peril (in danger). They must be protected rapidly.
- Accurately estimating the number of extinctions is impossible in areas like rain forests, where taxonomists have not even described most species.
- We are losing species that we do not know exist, and we are losing resources that could lead to new medicines, foods, and textiles.

Preservation of Endangered Species:

Saving species requires more than preserving a few remnant individuals. It requires a large diversity of genes within species groups to promote species survival in changing environments. This genetic diversity requires large populations of plants and animals.

Preservation of endangered species depends on a multifaceted (many-sided) conservation plan that includes the following components:

1. National Parks:

A global system of national parks to protect large tracts of land and wildlife corridors that allows movement between natural areas.

2. Protected Landscapes:

Protected landscapes and multiple-use areas that allow controlled private activity but also retain value as a wildlife habitat.

3. Zoos and Botanical Gardens:

Zoos and botanical gardens to save species whose extinction is imminent.

ENDANGERED SPECIES OF PAKISTAN

- In Pakistan, **Cheetah, Tiger, Asian lion, Indian cat, Indian rhino, Cheer pheasant, Crocodile, Gaviel** have been declared extinct.
- While, **Indus dolphin, Blackbuck, Common leopard, Great Indian bustard, Houbara Bustard, White-headed duck and Marbled teal** are among the animals near to extinction.
- Endangered species of plants have been recorded to more than 500.



EXERCISE

Q.1 Fill in the blanks.

- (i) Archaeobacteria can tolerate high temperatures up to _____.
- (ii) The first eukaryotes appeared about _____ years ago.
- (iii) _____ presented the theory of the origin of species by means of Natural Selection.
- (iv) _____ developed a theory of natural selection essentially identical to Darwin's.
- (v) _____ are considered to be the ancestors of all life.
- (vi) A respiratory protein called _____ is found in all aerobic organisms.
- (vii) Hardy Weinberg theory describes a _____ population.
- (viii) _____ is a series of changes in the genetic composition of a population over time.
- (ix) Level of classification between species and family is called _____.
- (x) Hardy Weinberg equation is binomial expansion of _____.
- (xi) An _____ species is in imminent danger of extinction throughout its species.
- (xii) A _____ is a localized group of individuals belong to the same species.
- (xiii) The first photosynthetic organisms used _____. As source of hydrogen for reducing carbon dioxide to sugars.
- (xiv) The first photosynthetic organisms used _____. As source of hydrogen for reducing carbon dioxide to sugars.
- (xv) _____ published an essay on "The Principle of Population".

ANSWERS

- | | |
|------------------------------------|-------------------------|
| (i) 120°C | (ii) 1.5 billion |
| (iii) Darwin | (iv) Wallace |
| (v) Prokaryotes | (vi) Haemoglobin |
| (vii) Gene pool | (viii) Non-evolving |
| (ix) Evolution | (x) Geneus |
| (xi) $(p + q)^2 = p^2 + 2pq + q^2$ | (xii) Endangered |
| (xiii) Population | (xiv) Hydrogen sulphide |
| (xv) Malthus | |



Q.2 Encircle the correct answer from the multiple choices.

- (i) The gill pouches of mammal and bird embryos are:
- (a) Vestigial structures
 - (b) Support for “ontogeny recapitulates phylogeny”
 - (c) Homologous structures
 - (d) Used by the embryos to breathe
 - (e) Evidence for the degeneration of unused body parts
- (ii) Darwin’s theory, as presented in the origin of Species, mainly concerned:
- (a) How new species arise
 - (b) The origin of life
 - (c) How adaptations evolve
 - (d) How extinctions occur
 - (e) The genetics of evolution
- (iii) The smallest biological unit that can evolve over time is:
- (a) A particular cell
 - (b) An individual organism
 - (c) A population
 - (d) A species
 - (e) An ecosystem
- (iv) A gene pool consists of:
- (a) All the alleles exposed to natural selection
 - (b) The total of all alleles present in a population
 - (c) The entire genome of a reproducing individual
 - (d) The frequencies of the alleles for a gene locus within a population
 - (e) All the gametes in a population
- (v) In a population with two alleles for a particular locus, B and b, the allele frequency of B is 0.7. What would be the frequency of heterozygote if the population is in Hardy-Weinberg equilibrium?
- (a) 0.7 (b) 0.42 (c) 0.49 (d) 0.09 (e) 0.21



- (vi) In a population that is in Hardy-Weinberg equilibrium, 16% of the individuals show the recessive trait. What is the frequency of the dominant allele in the population?
- (a) 0.84 (b) 0.36 (c) 0.6 (d) 0.4 (e) 0.48
- (vii) Selection acts directly on:
- (a) Phenotype (b) Genotype
(c) The entire genome (d) Each allele
(e) The entire gene pool

ANSWERS

(i)	(e)	(ii)	(a)	(iii)	(d)	(iv)	(b)
(v)	(b)	(vi)	(a)	(vii)	(a)		

Q.3 Short Question:

- (i) What are hydrothermal vents?**

Ans: See text.

- (ii) State Endosymbiont hypothesis.**

Ans: See text.

- (iii) Define population Genetics.**

Ans: See text.

- (iv) How does fossil record provide evidence of evolution?**

Ans: See text.

- (v) Explain the term homology with a suitable example.**

Ans: See text.

- (vi) What are vestigial organs? Give two examples.**

Ans: See text.

- (viii) State Harfy Weinberg theorem.**

Ans: See text.



(ix) What is the difference between Endangered species and Threatened species?

Ans: See text.

(x) name any five species, declared extinct in Pakistan.

Ans: See text.

Q.4 Extensive Question:

(i) What are the Endangered species? What measures could be adapted for their preservation?

Ans: See text.

(ii) State and explain Hardy Weinberg theorem.

Ans: See text.

(iii) Describe evidences of evolution from any five branches of biology.

Ans: See text.

(iv) How did evolution proceed from prokaryotes to Eukaryotes?

Ans: See text.

(v) Analyze the Darwin's theory of natural selection as mechanism of evolution?

Ans: See text.

